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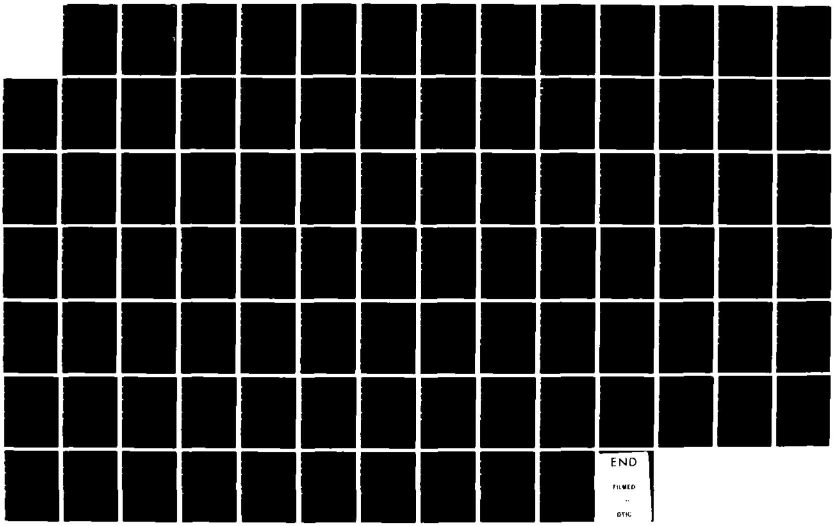

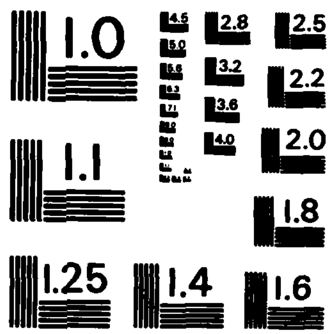

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Monterey, California

THESIS

SETTING TIME STANDARDS AT NISTARS

by

Raymond L. Miller

March 1984

Thesis Advisor: A. W. McMasters

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Setting Time Standards at NISTARS

by

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ABSTRACT

The Naval Integrated Storage and Retrieval System (NISTARS) is currently in the process of being installed at four Naval Supply Centers in the United States. These systems will automatically track, record, and direct movement of materiel from the receiving dock through storage to the final point of issue. Despite technological advances, accurate standards of anticipated materiel throughput for developing labor requirements have not yet been set at NISTARS.

Therefore, this thesis investigates the applicability of setting time standards at NISTARS activities. Various methods of determining standard times are reviewed. Governmental sources of standard times information are examined. The steps for developing standard times are provided. An example standard time for the rackables manned storage and retrieval machine is presented. It is concluded that standard times can and should be implemented at NISTARS to facilitate more accurate labor scheduling and to increase warehousing productivity.

TABLE OF CONTENTS

I. INTRODUCTION

A. BACKGROUND

The Naval Integrated Storage, Tracking, and Retrieval System (NISTARS) is currently installed and waiting completion of software to allow full implementation into the network of activities at the Naval Supply Center (NSC) Oakland, California. The NISTARS system in Oakland is a prototype of a system also being installed at NSC Norfolk, Virginia, NSC San Diego, California, and NSC Jacksonville, Florida at an estimated expenditure of $83 million. The system installed in Oakland provides over 800,000 storage locations and encompasses 834,193 cubic feet of storage space [Ref. 1].

The NISTARS system will automatically track, record, and direct movement of materiel from the receiving dock through storage to the final point of issue. NISTARS additionally provides a sophisticated conveyor system which eliminates most transportation of materiel traditionally done by fork lifts. NISTARS will keep current inventory information, automatically generate necessary documentation, automate most handling of materiel, and direct all movements through five interconnected Tandem computers. This provides an opportunity for these Navy warehouses to be among some of the most advanced warehousing activities in the country.

B. INTENT

Despite this progress in warehousing technology, accurate standards for the expected throughput of materiel have not been set at NISTARS, nor has an accurate assessment of output per man or standard times been established. An estimate of expected materiel throughput of the NISTARS system was part of the original contract specifications developed by Sperry in 1980 [Ref. 2].

However, this author is skeptical about using these numbers for several reasons. An example can be found in the time line analysis for the rackable Manned Storage and Retrieval Machine (MS/RM) [Ref. 2:G-37]. The time line analysis assumes there will be 1.25 stows for every 8.75 issues on a cycle of the MS/RM. The preference at NISTARS Oakland has been one stow for every four issues [Ref. 3]. The time line does not account for the travel of the MS/RM from the take-away conveyor on which the selected material has been placed, to the accumulation conveyor where the worker picks up the materiel to be stowed. This travel occurs once every cycle. The time line does not account for the time required to initialize the MS/RM, nor to press deadman controls to initiate the MS/RM travel. Additionally, the times which were established over four years ago have not beed adjusted to reflect changes in design unless those changes were anticipated to have created a different number of work stations which would require manning [Ref. 4].

Because of the many inaccuracies in the design of the time lines used in the original contract specifications, and the fact that those estimates were not updated to reflect changes in design, this author believes that the published specifications cannot be relied upon to provide an accurate assessment of materiel throughput per worker, nor can standard times be developed from those specifications to determine manpower requirements. This situation leaves NISTARS Oakland without standard times to estimate requirements, or an expected work output for each worker.

However, the lack of standard times in warehouses is not an unusual occurrence. Most warehousing activities do not even set standards [Ref. 5]. This results from a belief that warehousing activities are too varied and diverse to allow standardization of work methods.

The intent of this thesis is to provide guidance for establishing time standards for NISTARS. It will emphasize the methodology for setting, rather than providing actual standards for NISTARS. The examples provided in this thesis relate to manned storage and retrieval machines rather than fork lifts because the majority of manpower to be used at NISTARS will be in conjunction with MS/RMs. This thesis will also describe briefly the applicability of time standards with incentive plans, and their application to warehousing activities. Finally, other related subjects which should be considered when implementing standard times are discussed.

C. THESIS ORGANIZATION

Chapter II discusses standard times, the value of standard times, and some examples of current uses of standard times in warehousing activities, and in the Department of Defense. Chapter III discusses various methods of determining standard times. Chapter IV provides information regarding governmental sources of standard times information. Chapter V provides steps to use in establishing standard times. Chapter VI provides an example of how standard times can be used. Chapter VII describes information about auditing time standards, the need for union involvement, and the potential for incentive programs which can be used in connection with standard times. Chapter VIII summarizes the findings of this thesis, and makes recommendations for developing standard times as a major tool for management control of NISTARS activities.

D. METHODOLOGY

Prosecution of this research followed the general sequence of steps described in this section. Suitable background preparation was first completed. Preparation included a literature search of published material about standard times in warehousing operations. A study of standard times, their accuracy, and their applicability was also conducted. Various methods of establishing and maintaining standard times were reviewed. Incentive programs using standard times as a basis were studied.

The second major step involved discussions with industry personnel engaged in the use of standard times. Additional discussions were held with personnel involved in using computerized methods of setting and maintaining standard times.

During the third stage, an example of setting an actual standard time was developed using the rackable MS/RM. This standard time can be used as an example for setting other standard times in addition to providing a basis for determining anticipated throughput of materiel. Development of conclusions and recommendations based on the analysis completed this research.

II. STANDARD TIMES

A. STANDARD TIMES DEFINED

Mundel describes the standard time for a task as a:

> . . . function of the time necessary to accomplish a unit of work:
> (1) using a given method of equipment,
> (2) under given conditions of work,
> (3) by a worker possessing a specified skill on the job, and a specified aptitude for the job,
> (4) when working at a pace that will utilize, within a given period of time, the maximum physical exertion such a worker could expend on such a job without harmful effects. [Ref. 6:70]

Additionally, Mundel believes standard times which are used in industry should meet the following criteria [Ref. 6:73]:

1. Consistency. Standards should reflect the best practical manner of performing any particular task, and should be applied using the same techniques wherever used, adjusted for environmental or other unique considerations.

2. Attainability. The average worker should be able to attain the standard set, without harmful effects. The average worker is one who is fully trained, and physically fit for the intensity of the job. It should be possible for an excellent worker, with full concentration and effort, to exceed the standard.

Patton believes that a worker should be able to exceed that standard within a range of between 20 to 50 percent, which approximates 30 percent [Ref. 7:38].

B. IMPORTANCE OF STANDARD TIMES

Standard times allow the quantification of labor and equipment requirements for a particular task prior to performing that task. There are a number of benefits which accrue as a result of the use of standard times.

1. Increased Workforce Productivity

Productivity increases have proven to be significant when time standards are applied. Numerous studies have been conducted on the effect of work measurement and time standards use, and those studies have indicated that work measurements have a tendency to increase productivity of the workforce to a 80 - 90 percent performance level over a previous daywork level of between 60 and 65 percent [Ref. 8:14]. Daywork is a term used to describe any work for which the worker is compensated on the basis to time, rather than upon output.

Dr. Vincent Rueter believes that:

> . . . output under daywork conditions is so ineffective in most firms that immediate benefits in the form of cost reductions may be gained through the establishment of any work standards, regardless of how poorly they are established. [Ref. 8:15]

2. Better Utilization of Equipment

Management is able to determine how many pieces of equipment can be operated by one worker, or the utilization of a particular machine. This facilitates more efficient use of equipment, and a higher accuracy of equipment requirement predictions.

3. Provide Goals for Workers

The mere establishment of expected performance from employees provides those individuals a goal for which they may strive. Without a work standard, neither the worker nor his supervisors know precisely what amount of work is expected. The result is that the worker determines his own standards of quantity and pace, and the actual level of performance is likely to be lower than with an established standard.

4. Objective Examination of Methods

Creation of a standard time forces management to objectively examine the procedure and methods of performing work. The mere objective examination of the work process frequently affords management an opportunity to discover a way to perform that work in a more efficient manner.

5. Ease of Labor Supervision

Once standards are in place, undesireable practices which produce inefficient utilization of labor are quickly highlighted for the attention of management, allowing rapid correction.

6. Better Analysis of Proposed Work Methods

The quantification of work allows management the opportunity to compare proposed methods with more accuracy so that an optimal method can be selected.

7. Better Scheduling of Crews

Work crews which work either parallel or in sequence with each other can be scheduled more effectively, reducing

costly delays. Work accomplishment schedules can be established to allow the proper coordination of work with shipments, planned maintenance, or other services.

8. Emergency Response Planning

Emergency response planning becomes possible through the use of standard times. Management can determine maximum throughput of any area in the warehouse, and identify bottlenecks which can be eliminated, or activities which would be more effectively performed by additional personnel.

9. Establish Costs of Handling

An additional benefit is that costs of handling materiel can be established enabling a manager to determine the actual cost of receiving, inspecting, or issuing a piece of material. These costs can then be utilized in comparison with other activities to determine comparative efficiencies, or to give management the potential of utilizing them to establish incentive wages.

10. Justification of New Investments

Large investments in automation and other extensive mechanization can be justified through the use of standard times by simplifying the isolation of handling costs involved in the operation covered by the proposed equipment.

C. HISTORY OF STANDARD TIMES IN THE DEPARTMENT OF DEFENSE

In the early 1900's, as a result of the work of Frederick W. Taylor, the first effective applications of work measurement in government operations were made in Army

arsenals and Navy shipyards. This progressive trend toward standardizing labor was objected to by organized labor and was reversed in 1913 when Congress attached a rider to an appropriations bill stipulating no appropriation would be provided for the pay of any person engaged in time study work [Ref. 9:12]. This period of legislative prohibition against work measurement techniques in government lasted until the late 1940's.

In 1947, the House of Representatives passed a bill which allowed the War Department to use time study, and in 1949, the President signed Executive Order 10072, which directed agencies to:

1. Adopt modern management techniques,
2. Provide staffs for management improvement, and
3. Authorize the application of work measurement techniques within the government.

During the 1950's and 1960's, individual services developed independent programs following broad Department of Defense (DOD) guidlines. Two programs (the Warehouse Gross Performance Measurement System, and the Defense Integrated Management Engineering System (DIMES)) were established in 1965 in an attempt to improve logistics productivity. In March 1970, both programs were combined under the DIMES program. The objectives of the program were to improve labor productivity through the application of management engineering techniques, and to provide a data

base of work measurement data for budgeting, manpower requirements, and other management purposes. The program was further expanded in 1970 [Ref. 10 and Ref. 11].

D. CURRENT USES OF STANDARD TIMES IN WAREHOUSING

Despite the work done by the Defense Integrated Management Engineering System, it is still a widely held belief that warehouse jobs are too varied to allow time standards to be applied to them.

In 1978, the National Council of Physical Distribution surveyed a wide cross section of distribution managers, public warehouse operators, and transportation carriers, asking if they used standards for warehousing activities. They received 600 replies, of which only 15 percent indicated standards were in use for warehousing personnel [Ref. 5]. The grocery industry employed a significantly higher percentage of time standards than other warehousing activities. This is motivated by the requirement for rapid turnover in grocery warehousing.

Some warehousing activities outside the grocery industry have made impressive gains in productivity through the use of labor standards. Examples include Western Electric, Honeywell, and Warner Robins Air Force Logistics Center (AFLC).

Western Electric utilized time standards in their service center warehouses in the late 1960's and early 1970's, and discovered that despite an increase of 50

percent in volume of work, the size of the work staff increased by only 15 percent [Ref. 12:8].

Honeywell's receiving inspection department in Brighton, Maine achieved a productivity increase of 28 percent following their implementation of an indirect labor reporting system in 1980 [Ref. 13:49].

Warner Robins AFLC uses 859 work standards throughout its center to schedule requirements in materiel handling areas, control the workload assigned to workers, and to predict manpower requirements for potential projects. They justify requests for additional manpower ceilings based on these standards [Ref. 14].

III. METHODS OF DETERMINING STANDARD TIMES

Standard times are determined by computing the actual time it would take to perform a given task under ideal conditions, then taking those times and modifying and adjusting them to reflect real world conditions using real people.

There are five techniques of time study which can be used to determine actual times required to perform a certain task. They are direct observation, past performance, fiat, worker involvement, and previous time study data [Ref. 6].

A. DIRECT OBSERVATION

Time studies can be conducted by direct observation. Direct observation can be further divided into two methods, which Mundel calls "intensive sampling" and "extensive sampling". Intensive sampling is the method most often thought of by the average person when thinking of time studies. It consists of identifying the actual movements of the worker, and then using a stopwatch to time those movements. The current state of the art equipment is more sophisticated than a simple stopwatch. Video recordings or films are made of the worker and those films or tapes are measured. Intensive sampling is useful when conditions are very controlled, and the cycles of work are of less than a few minutes. These are not the circumstances encountered in most warehousing activities.

The extensive sampling technique is otherwise known as work sampling. A "snapshot" of the worker's activity is recorded every one-to-ten seconds [Ref. 9:221]. After a large number of these samples are taken, the percentage of time expended on various tasks is determined based on those observations, and time values can then be assigned to the work elements, based on those percentages.

B. PAST PERFORMANCE

Another technique used to determine standard times is the use of data from past performance. This is a method which statistically analyzes historical work output units, such as the number of issues, receipts, shipments, or any other variable which can be determined to be related to the amount of work which is involved. This work output is compared against the labor utilized for those same periods, and a standard time is computed for each output utilizing various mathematical approaches.

C. FIAT

Standard times may also be established by fiat. This happens when a function of a man's output is determined directly by the time spent at that activity. A good example is that of a security guard whose output is his physical and mental presence.

D. WORKER INVOLVEMENT

A fourth manner of obtaining work measurements is by involving the worker in the data collection. This can be

done through self-reporting, or by fractioned professional estimate. Self-reporting is done by the worker making a record of his activities and the time expended on those activities. A fractioned professional estimate is obtained by a worker, based on his experience, providing the best estimate of the time required for a certain task. The major difficulty in using this method is the degree of accuracy which can be obtained.

E. PREVIOUS TIME STUDY DATA

The most promising method of obtaining time study data for immediate use in establishing automated warehousing time standards is through the use of previous time study data. This data comes in two basic forms: predetermined time standards, and standard data. Predetermined time standards are based on time values for basic body motions. These motions are broken down into very small elements, and the times for these movements have been determined from a large number of direct observations.

1. Predetermined Time Standards

Methods-Time Measurement (MTM-1) is one of the most accurate and the most detailed form of predetermined time standards. This method is so detailed that it includes as a separate element the amount of time required for an impulse to reach the brain.

MTM-1 elements have been combined into larger time and motion elements to form MTM-General Purpose data.

The general purpose data system involves two levels of detail. The first, or basic level, provides the more common sequences of MTM-1 motions. The second, multipurpose level combines elements of the first. MTM General Purpose data can be used by engineers who have been certified by the MTM Association, and is accurate within 15 percent of MTM-1 for cycle times over .12 minutes in 95 percent of the cases [Ref. 9:474].

MTM-2 is the second general level in a further simplified grouping of body motions, and is less refined. It is suitable for the majority of motions, and is recommended where the human part of a work cycle exceeds one minute, and the cycles are not highly repetitive. The work cycle should not involve complex or large numbers of simultaneous hand motions. Certified engineers should also be used for MTM-2 [Ref. 9:475].

MTM-3 uses still larger blocks of time than MTM-1, MTM-2, or MTM General Purpose. It is used in situations where the work cycle is in excess of four minutes, and the frequencies of body motions do not exceed ten times per cycle [Ref. 9:481].

2. Standard Data

The second grouping of historical time study data are accumulated for broad movements. Standard data tables provide results from a very large number of various types of time studies over a large amount of time, insuring

"average" data and reducing the effect of variables which may impact on the validity of data. An excellent source of this data has been made available in 11 volumes of the Department of Defense Manual DOD 5010.15.1-M, and is the mandatory source of standard time data for each DOD activity where labor performance standards are developed and applied. This source of data can be used by people other than trained engineers.

Some advantages of the use of standard data are listed below [Ref. 15:595]:

a. Reduced cost of standards development,

b. Greater consistency and accuracy of standards,

c. Increased coverage of work which is not highly repetitive,

d. Establishment of standards in advance of production, and

e. Ease of maintenance.

Standard data does not come without disadvantages. These include the initial cost of development, and the effects of averages and frequencies.

Finally, it is imperative these developed times are adjusted to reflect real world conditions. The tables and charts provide what is known as work time or base time, which is the time which would be required for completion of the task under the circumstances described as standard, without consideration for the operator's personal needs,

fatigue, time lost to delays and interruptions, or time lost due to other miscellaneous causes beyond the operator's control. These factors must be used to adjust the base time upwards to provide a true picture of an operator's performance over an eight-hour day.

F. THE USE OF COMPUTERS

Computers are ideally suited for establishing and maintaining standard time data. The biggest advantage of using a computer is for easy updating of standards which, through the normal maintenance process, will routinely be adjusted only slightly. If a method, equipment, environment, or personnel policy changes, all affected standards could be changed with a comparatively small degree of effort.

Work measurement software is currently finding its way to the market. An example of state of the art software currently in existence is the 4M-mod II program which uses MTM-1 data to achieve the same level of precision as MTM-1. The 4M-mod II program subdivisions produce more than 20,000 time increments. Warehousing functions do not require this degree of sophistication, however, as the work cycle times are relatively long and not highly repetitive.

There are at least three standard data software programs currently available which are useful in maintaining warehousing standards.

1. Brief Work Factor

One program, called the Brief Work Factor program, uses basic motion times. Basic motion times are a collection of time standards assigned to fundamental motions, or grouped motions which cannot be economically determined by intensive observation procedures. The values are synthetic in that many of these work motions are grouped through logic. Science Management Corporation (originally known as the Work Factor Company, Inc.) developed work factor data in 1938 after four years of research and gathering of data. These time standards were combined into three levels of detail: Detailed Work Factor, Ready Work Factor, and Brief Work Factor.

Detailed Work Factor has eight elemental descriptions, and its motion-time table contains 764 time values. The use of Detailed Work Factor, like that of MTM-1, is primarily for short cycle, highly repetitive jobs [Ref. 9:452].

Brief Work Factors can be learned and used by people who do not have extensive training in time study, or other work measurement techniques. A computer program has been written using Brief Work Factors, and tested on the TRS-80 and Apple II Computers. The program is interactive, and asks the user if he needs instructions on how to use the program. The program will then ask the user to enter the description of the operation, according to a specified format. If the element is not exactly listed as

in the work segment tables, the user enters the most similar element. The program then produces both elemental, as well as operational times. The program can accept 100 elements per operation, and it is possible to expand the size [Ref. 16: 18].

2. Automated Data Application and Maintenance

Automated Data Application and Maintenance (ADAM) is another system which lends itself well to generating and maintaining labor standards through the use of previous time study data. ADAM uses the Pascal language, and is designed to be operated on microcomputers. Unlike most computer based systems, ADAM does not require users to fill out a rigorously drawn input form. ADAM 2 uses MTM-2 data, and is the MTM data system which is most applicable to warehousing. ADAM 2 uses ten basic elements: get, put, apply pressure, regrasp, eye action, crank, step, foot motion, bend and arise, and weight factor.

ADAM inputs are of six types: descriptive comments, element codes, frequencies, standard data elements, and object names. ADAM will provide such functions as accepting and checking a sequence of motion codes constituting an operation, detecting errors in inputs, storing standard data elements, evaluating formulas, and printing completed studies [Ref. 17:14-18].

3. Computerized Standard Data

Another system on the market which applies itself readily to data contained in DOD 5010.151-M is Computerized

Standard Data (CSD). CSD has no built-in data base, but rather uses a company's own data. This computerized standard data program has the advantage of easy tailoring to DOD standards which have already been approved for use. Unfortunately, it requires the laborious process of data entry for all time elements upon initial use [Ref. 18:42].

The use of computers in standard times maintenance is increasing rapidly, and based on the current interest expressed in various periodicals, this author believes this trend is expected to continue. Other software programs should be commercially available within the next few years.

IV. GOVERNMENT SOURCES OF TIME STANDARD INFORMATION

There are two primary government data sources for establishing time standards for Navy warehousing activities. They are the DOD Manual 5010.15.1-M, and the NAVSUP Publication 529. The former provides detailed information on establishing time standards, and is the primary DOD approved source of standard time data. The manual states that maximum use of these standard time data is mandatory at each Department of Defense activity where labor performance standards are developed and applied. If the standard time data in the DOD manual is not applicable, other sources of data may be used. The latter is a warehouse modernization and planning guide which provides a methodology for different picking systems.

A. DEFENSE WORK MEASUREMENT TIME DATA PROGRAM MANUAL

1. Use

The Defense Work Measurement Time Data Program Manual (DOD 5010.15.1-M) has one of the more extensive listings of standard data found. DOD 5010.15.1-M data was first available on 1 March 1967, and described work elements in large blocks of time.

This manual was further refined in 1974-77, and now utilizes a lower level of elements in the building of data to facilitate more accurate application. At the time of the

writing of this thesis, the manual is out of print. However, copies are still available at DOD activities which maintain time standards.

2. Purpose

The purpose of the DOD 5010.15.1-M is to "standardize instructions, guidance, methods, terminology, and standard time data applicable to work measurement and the development of labor performance standards" within the Department of Defense [Ref. 19].

3. Organization of the Manual

There are 11 volumes within the DOD manual. These consist of a basic volume, nine occupationally oriented volumes, and one volume which contains data which can be applied to a large number of occupations. The volumes which pertain to warehousing time standards include the basic volume, volume two, nine, and ten.

The basic volume includes an overall introduction to the manual, coding structures, examples on the use of the manuals and forms, and the use of the data contained in the manuals. The basic volume includes the general information needed about the organizational levels of the manual, DOD approved modifying variables, and the degree to which time elements may be adjusted based on those variables. The basic volume also has an introduction and appendices which may be useful in establishing a work measurement program [Ref. 19].

Volume two contains data for clerical and sales operations. This data is needed for such time elements as keying in pick item identification numbers, or signalling to the NISTARS computer that a transaction is complete [Ref. 20].

Volume nine is the miscellaneous occupations volume. It includes materiel handling, packaging, and transportation data. This is the volume which would be used most frequently in establishing time standards in warehousing [Ref. 21].

Volume ten is the volume which contains universal standard time data which is applicable to many different occupations. This manual includes time data for such general movements as picking up an object or walking [Ref. 22].

Each volume contains two parts. Part one provides guidance in addition to general information, and an explanation of the coding used. Part two provides the Defense Work Measurement Standard Time Data (DWMSTD).

The standard data provided in the volumes is further divided by occupation codes which codify and index catagories most likely to be found in certain activities. Activities most likely to be found in packaging and materiel handling occupations, for example, are found under occupation codes beginning with a 92,indicating volume nine, category two. Those groups are then further divided into subgroupings which are related to actual functions. Occupation code 92, for example, is further divided into:

Category	Function
920	Packaging Operations
921	Hoisting and Conveying Operations
922	Material Moving & Storing Operations
923	Packaging and Material Handling

4. Operation/Element Descriptions

Each work segment described in DOD 5010.15.1-M is clearly defined, with a descriptive statement describing the precise point when the work element begins, what is included in the element, and a definitive point where the element stops. For example, the element description to pick up a 2,000 pound pallet off the floor with an electric fork lift can be found in volume none [Ref. 21.91]. The element description is:

> Pallet (Loaded-2,000 pounds), pick up with an electric forklift
>
> Starts--with start of forklift truck
>
> Includes--All the time necessary to run in ten feet, lower forks six inches, forward (slow) into pallet, raise forks 24 inches and tilt
>
> Ends--with forklift truck ready to travel.

5. Codes and Indicators

The manual uses several different codes and indicators in providing information about the data which are being used. These codes provide information as to where the data originated, accuracy of the data, how the data were obtained, and for what purpose the data are provided. Some of the more important codes are explained below.

a. Data Source Code

Every element described in the manual has a data source code. This is a two-letter or three-letter code making it possible to determine where backup data is maintained. The first digit designates the major organizational activity which submitted the data. For example, the Marine Corps developed much of the warehousing information, and is designated the letter "M". The letter "D" ndicates either that the data was developed by the Defense Industrial Resource Support Office (DIRSO), or that data was submitted to DIRSO from another activity, and subsequently underwent major revisions to the degree that backup information directly from the originating activity would not support the data.

The second and optional third characters identify the major organizational entity and activity which developed the data. The Marine Corps Supply Center, Albany, did much of the warehousing studies, and has been designated the letter "A" for the second letter.

b. Quality Code

The quality code is a three-letter code which identifies the technique used to develop the data, the statistical reliability of that data, and a functional indicator.

c. Technique Indicator

The technique indicator identifies the predominant measurement technique used in developing that

particular standard time data element. The codes used in the manual are listed below:

Code	Technique of Development
M	MTM Based Data
O	Other Predetermined Time Systems
T	Time Study
W	Leveled Work Sampling
F	Manufacturer's Specifications (Machine Times)
S	Statistical Time Data
E	Technical Estimate
A	Manhour allowance

d. Quality Indicator

The quality indicator is a code which identifies the statistical reliability of the standard data element. These codes are listed below:

Code	Confidence Level	Degree of Accuracy
A	95%	5%
B	95%	10%
C	90%	10%
D	90%	25%
E	90% or less	Over 25%
U	Unknown or Indeterminate	

e. Functional Indicator

The functional indicator identifies standard time data elements for the type of work. If two data elements appear similar in the manual, the user can select the function indicator which is most applicable. For example, the Supply Operations indicator consists of an "L", and the Administration indicator was assigned the letter "M".

f. Element Source Code

The element source code is a code which the developer of the data assigns to cross-reference his data, and is

used in case of questions from potential users. This code is not normally significant to the user.

g. Data Element Code (DEC)

The Data Element Code is a seven-character, alpha-numeric code which identifies each element as to its scope and potential use. The first character is the most important for the user, and indicates the level of data groupings and the format of the data. For example, in the first column, the reader may see the letter "T", which indicates the data is arranged in a format of columns and rows to simplify presentation. Tabular data is read column first, and row second. The first letter codes and associated levels are:

Code	Description	Level
B	fundamental or basic motion	1
M	multipurpose	2
T	tabular	
S	special purpose	3
K	task	4
J	job (highest level of standard time)	5

The fundamental motion or basic motion, like that described in MTM-1, is the smallest subdivision of human work, and is considered too small for economical use. It is not generally included in the manual.

h. TMU Code

The acronym TMU stands for "time measurement unit". There are 100,000 time measurement units in one hour. The times for the various work elements described

in DOD 5010.15.1-M are provided in TMU units. The following table provides a conversion to more commonly used measures of time:

1 TMU	=	.00001 hour
	=	.0006 minute
	=	.036 second
1 second	=	28 TMU's
1 minute	=	1,667 TMU's
1 hour	=	100,000 TMU's

7. PFD Allowances

Personal, Fatigue, and Delay (PFD) is a term used to describe the time allowed a worker for attending to personal needs, slowdown of work or rest periods due to fatigue, and for delays occurring due to conditions beyond his control. Appendix II of the basic volume provides modifiers and adjustments which are authorized to be made to the base times. Use of delay allowances other than those listed in Appendix II requires an engineered backup study in accordance with the directions of the Defense Industrial Resources Support Office [Ref. 19:A-II-9].

B. NAVSUP PUBLICATION 529

Another less refined source of labor standards can be found in the Warehouse Modernization and Layout Planning Guide (NAVSUP Pub 529). This guide details five methods of order picking, seven methods of stowage of receipts, and considers times. The publication also provides suggestions for planning installation of a new or remodeled warehouse facility. In particular, these suggestions

consider both selection of equipment and warehouse configuration, and are based on projected building and labor costs [Ref. 23]. The significant contribution from this publication toward the establishment of time standards in warehousing is the detailed explanation of the methodology used in computation of transaction times and base unit pick times. These are contained in the Appendices of NAVSUP Publication 529.

1. Transaction Times Analysis

Transaction time analysis consists of taking the height and length of the shelves, and determining the length of time to travel those distances based on the travel speeds of the particular vehicle used. As a Storage/Retrieval machine can travel both horizontally and vertically at the same time, both times are computed, and the most restrictive time for any segment is then determined to be the travel time. Vertical travel is assumed to be the limiting factor for the Storage/Retrieval machine example in the NAVSUP Publication. Materiel is assumed to be randomly distributed on the shelves without consideration to popularity of the item.

The distance of travel computed for an average one-stop cycle is assumed to be half the length and half the height of possible vehicle travel per aisle. The distance of travel computed for an average two-stop cycle assumes the second stop to occur in half the remaining

distance. It is assumed that for 50 percent of the time the Storage/Retrieval machine has a single-stop cycle, and the remaining 50 percent of the time it has dual-stop cycles. Transaction times are then computed and compared to alternative systems. The standard transaction time computed for a Storage/Retrieval machine and a pallet handling system ten levels high is only 1.68 minutes per transaction. A fork lift requires 2.06 minutes per transaction.

2. Base Pick Times

The base pick time consists of the sum of the times of elements other than travel within the aisle, including their anticipated frequencies on an assumed base of 100 line items issued in ten orders per work cycle, corrected for PFD. The following example provides computation of base pick times. Note that items 3, 5, 8, and 10 do include travel. However, this travel time is the travel time which it takes a fork lift to travel to and from the central desk which is located 50 feet from the end of the aisle, and not travel within the aisle. The latter is computed separately in the transaction times analysis. Those elements, and associated times (according to the NAVSUP publication for a manned Storage/Retrieval machine) per issue are shown in [Ref. 23:19-27]. The subtotal for 100 line items issued per cycle is 17.7 minutes. When an assumed average of 20 percent PFD factor for warehousing

activities is added, the result is a total base time of 21.2 minutes for 100 issues. Base time per issue is then computed at .212 minutes:

	Element	Time/min	Frequency
1.	Pick up orders from central desk and read	.6	1
2.	Place empty totes boxes on platform	.1	10
3.	Travel to pick aisle (.0025 min/ft)(50 ft)	.2	1
4.	Pick merchandise and mark document	.15	100
5.	Travel from pick aisle (.0025 min/ft)(50 ft)	.2	1
6.	Place tote boxes on take-away system	.1	10
7.	Load replenishment mdse. on table	.8	.01
8.	Travel to pick aisle (.0025 min/ft)(50 ft)	.2	.01
9.	Restock bins	.08	1
10.	Travel from pick aisle (.0025 min/ft)(50 ft)	.2	.01

Since vertical travel time within the aisle is the limiting factor, this time divided by the 100 issues per cycle is added to the base pick time to determine the unit pick time. The NAVSUP Publication 529 adds the unit pick time to travel and start/stop times to arrive at an average pick time of 1.68 minutes per pallet [Ref. 23:19-19]. Once a unit pick time is determined, it becomes a simple

mathematical exercise to determine labor requirements, labor costs, and throughput capabilities.

3. Critique

It is this author's belief that the general methodology described in the NAVSUP Publication provides an excellent guideline for establishment of base pick and unit pick times. However, extreme caution should be exercised in using the unit times published to determine standard times.

There are a number of assumptions used in this publication, some of which should be viewed with some degree of skepticism. The publication makes the assumption that an average of ten orders and 100 issues are pulled per cycle, yet it provides for only an average of 1.5 stops during the cycle. It is not often that ten orders can be pulled using such a small number of location stops. Another area of concern is the .15 minutes assigned to pick and mark the document per issue (which the author considers an unreasonably short period).

The NAVSUP Publication is currently in the process of revision. Pick and documentation times for the manned SR machines in the new manual (element four in the example above) have been adjusted to 1.44 minutes per issue. This is based on the anticipated usage of a DD-1348 being manually filled out by the stock picker. This will not be applicable to the automated documentation preparation which is part of NISTARS.

The new NAVSUP Publication uses the 1 March 1967 version of the DOD 5010.15.1-M manual to avoid the detailed standards of the later version of the manual. As a result of this, and the fact that no correction is included for improvements made in the last 17 years, some loss of accuracy can be expected [Ref. 24].

Finally, it should be emphasized this publication was designed primarily as a guide for selecting warehouse systems. Thus, the data contained in that publication is intended for comparison of the alternative systems described. In spite of these shortcomings, this publication may provide both methodology and certain element times which are useful in establishing standard times.

V. STEPS IN SETTING TIME STANDARDS USING DOD 5010.15.1-M

A. IDENTIFY METHOD

The first step in setting time standards is to study the work to be standardized, or to develop the steps for doing the work if the steps do not already exist. In this process the analyst should consider the best practical method of performing the task. Every operation, movement, delay, inspection, or control should be analyzed as to what, where, why, when, and how it is to be performed. Some of the basic questions which the analyst should ask include [Ref. 25:49-51]:

1. Can any operation be eliminated, combined or reduced?
2. Can any movement be eliminated, combined, or reduced?
3. Can delays be eliminated, combined, or reduced?
4. Can countings or inspections be combined, or made easier?

One method which is useful in making a detailed study of an operation is the flow process chart method. The flow process chart is a formalized chart used to portray graphically the step-by-step procedure of performing the work. The flow process chart (DD Form 1723) is a common form used by industrial engineers, and is readily available through the Navy Supply System. The use of this form reduces the chance of neglecting a step in the process, aids in frequency

determinations, and facilitates the choice of an optimal method of practical work practices.

B. COMPUTE WORK ELEMENT TIMES

1. Select Work Element Times

Once the detailed study of the operation has been completed, and a method of work accomplishment has been established, it is necessary to identify start and stop points of the various work elements. Suboperations also need to be identified and described. The major benefits of the breakdown into work elements and suboperations are [Ref 7:28-29]:

a. It allows the activity to be divided into manageable steps,

b. It makes standard revisions easier to apply when changes in work methods occur, and

c. It makes it easier to convince supervision that the standard time values developed using this approach are representative of the time required to do the work activity.

The selection of work elements may be difficult. It is recommended that the analyst review the contents of his primary source of data prior to selecting the work elements to allow a closer alignment of units with data elements in the source manual.

2. Compute Work Element Times

The operations and suboperations from the time study can be compared for direct applicability with the work elements described in DOD 5010.15.1-M. The analyst's familiarity with the source data will reduce the complexity of this task.

If the operation described in the detailed study is compatible with the elements described in the Defense Work Measurement Standard Time Data Program (DWMSTDP), then the procedure outlined in the manual can be followed. The element will indicate whether the Time Measurement Unit (TMU) to be associated with a work element is constant, variable, or a combination. Variable TMU's can be determined from a table, multiple case description, or through simple mathematics.

Care should be exercised prior to adjusting any DWMSTDP element, as these elements have been carefully constructed to provide average data. This provides a high degree of accuracy in most cases.

Local standards may be developed for elements not matching the DWMSTDP, by using another source of data, or using historical local times. Local times may be determined by any of the five methods of determining time standards discussed previously in Chapter III.

C. CHOOSE FREQUENCIES

The choice of frequencies and occurrences is probably the most crucial decision in terms of the effect on the

value of time standards an analyst can make. If an average order picking cycle consisting of four picks and one stow is mistakenly assumed to consist of eight picks and two stows, the standard time can be altered by as much as 15 percent. This can happen because certain parts of an average time, such as travel time, will be consumed for a worker to complete a cycle, regardless of the number of work units which are accomplished.

For example, a worker will travel approximately the same horizontal distance of an aisle up and back, whether he picks eight or four items during that round trip. That time he travels will be divided by eight to determine the average time for an eight-pick round trip. That time per pick will be twice as long if he only picks four items. This frequency decision should not be made without serious thought and consideration to past historical data.

D. DEVELOP TIME STANDARDS PER CYCLE

The next step is to compute time standards for every work cycle. A work cycle is a pattern or sequence of manual motions, elements, activities, and operations that is repeated without significant variation. An example of a work cycle would be the time and motions required for a MS/RM operator to go from the point where he picks up his stows at the accumulation conveyor, until he returns to the accumulation conveyor at the same point.

First, the element times are summed and weighted by their frequencies. Frequencies should be applied to all elements. If an element occurs six times during a cycle, that element's time value should reflect six times the element TMU provided in the DWMSTDP. If an element occurs less frequently than once per cycle, the expected frequency of occurrence is still multiplied by the element's individual TMU.

PFD allowances are then made to the total operation or cycle rather than to each element unless machine controlled times are involved. Machine controlled times are times which cannot be altered by the worker, regardless of the worker's effort, and are solely dependent on the control of the machine. Times expended on fork lifts or MS/RM machines are not machine controlled times, as the driver can affect the speed which these machines can travel.

E. DETERMINE STANDARD TIMES

Once the standard time for an average work cycle is determined, the time established for the cycle can be divided by the number of output units of work measurement. An output unit is a measureable item which results from a worker's labor. An item stowed on a shelf is an example of an output unit.

The times should be separated into constant times and variable times. Constant times are times which are constant per work unit. These times will not change regardless of

the frequency of the work unit, such as that found for the actual pick of a unit of an item from the shelf.

Variable times are times whose values will vary with the number of work units achieved. Items such as transportation times, or a common work element which serves more than one output qualify as variable times.

F. DETERMINE MANPOWER REQUIRED

Standard times determined for units of output can now be multiplied by the anticipated workload to determine man-hour requirements, equipment needs, or anticipated throughput of materiel.

G. VALIDATION

Once standard times data have been developed, they should be tested and verified prior to implementation. All equipment, work processes, frequencies, and environmental conditions should be verified to ensure correctness. A dry run may be appropriate with a worker's progress being checked at various points. This validation should be recorded. More complicated or extensive standard time data should involve more detailed and extensive reviews before implementation.

VI. AN EXAMPLE OF USE OF STANDARD TIMES

This chapter will provide an example of the development of standard times in warehousing. Most manpower used in moving materiel at NISTARS is in conjunction with the use of MS/RM's. The largest number of storage locations within MS/RM positions are the rackable MS/RM's.

A. SCENARIO

For the illustrative purpose of this example, it is assumed the operator of the MS/RM (Manned Storage and Retrieval Machine) also has been assigned tasks other than the operation of one MS/RM machine. This results from NISTARS being designed to handle larger than normally expected workloads, thus providing excess capacity at each station. A worker is expected to work faster than the anticipated throughput at each station, and therefore should be able to work more than one station [Ref. 3].

At the initialization of work onboard the MS/RM, the operator boards the MS/RM at ground level at the end of the aisle, inserts an identification card into a reader, and keys in a six digit identification code. He proceeds to the MS/RM controls, where he initiates the travel vertically 27 feet to the accumulation line, and the materiel to be stowed is brought aboard. The MS/RM operator must

have both feet and both hands on pressure operated levers for the machine to move [Ref. 2: Chap. II].

After picking up the materiel to be stowed from the accumulation line, and wanding in the Stowage Identification Number from that materiel into the MS/RM terminal with a bar-scanning wand, he places the materiel onto the rack at one end of the MS/RM. The MS/RM terminal Cathode Ray Tube (CRT) then directs the operator to travel to the most efficient choice of stopping locations, and indicates what action he should take at each stop.

Because the preference of stows and picks at NISTARS Oakland has been one stow for every four picks, this will be assumed to occur for every anticipated cycle of the MS/RM. The aisle length is 189 feet, and the top height of the floor of the MS/RM can travel is 32 feet. The base of the MS/RM floor is 18 inches above the ground [Ref. 3].

Picks and stows are made from an upper band of 20 feet of the aisle during the trip down the aisle, and a lower band of 20 feet of the aisle during the trip back. The average vertical travel between transactions is 10 feet [Ref. 2]. The average horizontal travel between transactions is 22 feet.

If the instruction to the operator on the CRT is to pick, he follows the picking instructions. He may be instructed to pick a full carton, or to pick less than a full carton. If a full carton pick is directed, the

operator reads the National Stock Number (NSN) from a label with a bar code scanner wand. The operator applies a Pick Identification Number (PIN) label to the materiel, wands the label, and stows the materiel on the MS/RM shelves. If less than a full carton is directed, the operator removes the materiel from a carton, replaces the carton on the aisle shelf, places the materiel in a bag with the PIN label applied, and places the bag in a tote tray. He places the tote tray on the MS/RM shelving after setting routing numbers on the tray.

If the instruction is to stow, the operator picks up the receipt from the MS/RM shelves, scans the Storage Identification Number (SIN) with the scanning wand, and places the materiel on the proper aisle shelf with the NSN label facing the aisle.

After completing his picks and stows, the operator aligns the MS/RM with two take-away conveyors. He positions the MS/RM so the carton take-away conveyor is at waist height, and the tote take-away conveyor is located 3.5 feet below it. He then unloads his picks onto these conveyors.

It is assumed the operator completes five cycles, travels to the end of the aisle at ground level, and discontinues work at that MS/RM to work at another MS/RM located in the same vicinity during normal work loads [Ref. 3]. During heavy demand, such as that experienced

during a time of national emergency, the operator would pick eight items and stow two items during a cycle. He would not leave his machine during the normal workday to work elsewhere.

B. DETERMINE STANDARD TIME SPECIFIC TO PICK

The standard time which is specific to a pick includes the time expended actually picking the issue from the shelf and the time expended in placing those issues on the take-away conveyors.

1. Pick Issue from Shelf

Element Description	Fre-quency	Time in TMU's	Comments Source (DOD 5010)
Read and retain six digit location from CRT	1	131	v.X p.77
Move to controls	1	97	v.X p.8
Sit and stand stationary chair	1	108	v.X p.6
Press and control deadman switches	1	70	v.X p.A1
Read and verify five digit location	1	177	v.X p.8
Move to door	1	97	v.X p.8
Turn to CRT	1	50	v.X p.8
Read pick quantity	1	57	v.X p.8
Wand NSN lable	1	150	fractioned estimate
Remove part from box and replace box on aisle rack	.25	173	v.IX p.26
Turn to tote box	.25	50	v.X p.8

Element Description	Fre-quency	Time in TMU's	Comments Source (DOD 5010)
Get tote box	.25	75	v.IX p.14
Turn to console	.25	50	v.X p.8
Get paper bag, open bag in tote, insert materiel, close bag	.25	204	v.IX p.17
Read slider numbers from CRT	.25	113	v.X p.77
Set four sliders on tote	.25	108	v.X p.77
Attach PIN label	1	135	v.II p.17
Wand PIN label	1	150	fractioned estimate
Turn to rack	1	50	v.X p.8
Place mat'l on rack	1	74	v.IX p.15
Turn to CRT	1	50	v.X p.8
Enter transaction complete	1	15	v.II p.B-10
Total Time for Pick		1604 TMU's	
Total Constant Time Per Pick		1604 TMU's	

The time to scan the labels using a wand were not obtained directly from the DOD 5010.15.1-M publication, but rather, as the sum of two subelements. The fractioned estimate was determined by breaking the operation into two parts. The first included picking up an object, getting control of the object to use, and moving the object aside. A TMU value of 43 was found in Volume X, page 75. The author determined the closest activity to the actual wanding of the label to

be that of lining out an item on a worksheet with a pen or pencil. This was located on page 28, Volume II, and had a TMU of 105. The 148 TMU total was rounded to 150 in deference to the imprecision of combining the two operations to simulate the wanding process.

2. Place Issue on Take-away Conveyor

Placing an issue on a take-away conveyor consists of both constant and variable elements. The variable elements have times which relate to the entire activity, and not to one specific issue. If, as expected, there are more picks than one per cycle, the time which is devoted to the act of stopping the MS/RM will apply to all of the issues. These various times must be applied equally to each issue, and thus, the times will vary depending upon the quantity of issues. These fractional times will be distinguished from the constant times in the comments section.

Element Description	Frequency	Time in TMU's	Comments Source (DOD 5010)
Move to controls	1	97	v.X p.8 V
Sit and stand stationary chair	1	108	v.X p.6 V
Control deadman switch	1	70	v.X p.A-1 V
Move to rack	1	97	v.X p.8 V
Pull mat'l from rack	4	75	v.X p.14 C
Turn to door/rack	8	50	v.X p.8 C
Turn to door/rack	-1	50	v.X p.8 V

Element Description	Fre-quency	Time in TMU's	Comments Source (DOD 5010)
Place tote on take-away	1	103	v.IX p.15 C
Turn to CRT	1	50	v.X p.8 V
Enter transaction complete	1	15	v.II p.B-10 V
Total Time for placing 4 issues		1364 TMU's	
Total Constant Time per issue		244 TMU's	
Total Variable Time per cycle		387 TMU's	
Total Variable Time per issue (387/4)		98 TMU's	

A negative value occurs once for any stop which has the potential of serving more than one piece of materiel movement. The worker for a pickup of more than one stow from the accumulation line, or the placement of more than one issue on the take-away conveyor, will make two times the number of turns to the door/shelves on the MS/RM minus-one. To account for this, a negative variable has been added to each of these occurrences.

C. DETERMINE STANDARD TIME SPECIFIC TO STOW

The standard times which are specifically associated with the stowing operation are the times expended in actually moving the materiel from the MS/RM to the aisle shelves, and the time picking the materiel from the accumulation line at the beginning of the cycle.

1. Stow Time from MS/RM

All times to stow items from the MS/RM are considered constant times.

Element Description	Fre-quency	Time in TMU's	Comments Source (DOD 5010)
Read and retain 6 digits	1	131	v.X p.77
Move one step to controls	1	97	v.X p.8
Sit & stand-stationary chair	1	75	v.X p.6
Operate deadman controls	1	70	v.X p.A-1
Read & verify bin location	1	177	v.X p.77
Move to shelf	1	97	v.X p.8
Pick up mat'l to be stowed	1	75	v.IX p.14
Turn to CRT	1	50	v.X p.8
Read-verify NSN, 4-digits	1	94	v.X p. 78
Wand label	1	150	fractioned est.
Turn to door/rack	1	50	v.X p.8
Stow mat'l label out	1	74	v.IX p.15
Turn to CRT	1	50	v.X p.8
Enter transaction complete	1	15	v.II p.B-10
Total Time for stow action		1205 TMU's	
Total Constant Time per stow		1205 TMU's	

2. Pick up Materiel at Accumulation Line

Element Description	Fre-quency	Time in TMU's	Comments Source (DOD 5010)
Move to controls	1	97	v.X p.8 V
Sit/Stand stationary chair	1	108	v.X p.6 V

Element Description	Frequency	Time in TMU's	Comments Source (DOD 5010)
Control deadman switches	1	97	v.X,p.8 V
Move to door	1	97	v.X,p.8 V
Pick mat'l from accumulative conveyor	1	75	v.IX,p.14 C
Read 4 digit SIN	1	67	v.X,p.77 C
Turn to CRT	1	50	v.X,p.8 C
Key 4-digit SIN	1	39	v.X,p.B10 C
Enter transaction complete	1	15	v.II,p.B10 V
Turn to doors/racks	2	50	v.X,p.8 C
Turn to doors/racks	-1	50	v.X,p.8 V
Place mat'l on rack	1	74	v.IX,p.15 C
Place tote on rack	1	74	v.IX,p.15 C
Total Time for stow pickup		816 TMU's	
Total Constant Time per stow		479 TMU's	
Total Variable Time per cycle		337 TMU's	
Total Variable Time per stow		337 TMU's	

D. DETERMINE COMMON TIMES

Common times are times which cannot be specifically identified to one occurrence within the cycle. Common times include times such as travel times of the MS/RM, the time to initialize or disembark from the MS/RM every five cycles, or the vertical time expended in travel from the end of one cycle to the start of the following cycle.

1. Initialization/Disembarkation of MS/RM

All times for the Initialization/Disembarkation are variable times.

Element Description	Fre-quency	Time in TMU's	Comments Source (DOD 5010)
Board/disembark MS/RM	1	129	v.IX, p.1
Turn to keyboard	1	50	v.X,p.8
Enter badge into keyboard	1	47	v.II, p.40
Key in 6-digit employee number	1	55	v.II, pp. B10-11
Walk to controls	1	97	v.X, p.8
Sit and stand, stationary chair	1	108	v.X, p.6
Engage deadman controls	1	70	v.X, p.A1
Remove badge	1	47	v.II, p.40
Turn to disembard	1	50	v.X, p.8
Turn to CRT	1	97	v.X, p.8
Total Time for initialization/ disembarkation		750 TMU's	

2. Travel Times

The travel times for the MS/RM can be computed by adding the travel time which is constant to the fractional variable time. The constant time is the average time which it will take to travel between stops made during a cycle. The variable times are those times which will vary depending on the number of stops to be made during the cycle, plus the fractional time required for initialization and disembarkation travel when the operator leaves the MS/RM for any reason.

a. Constant Times

As each pick or stow is made within a 20 foot

vertical band, each pick or stow will have an average of 10 feet vertical travel. It is assumed the average stop requires slow vertical travel two feet before, and one foot after each stop to allow alignment of the MS/RM with the stopping location, and to reduce the jolt to the passenger, materiel, and electronic controls on board. The limiting travel speed is vertical travel. The speeds and distances travelled are as follows:

(1) MS/RM Speed (TMU's per Foot):

MS/RM Speed	Fast	Slow
Horizontal	6.6	22.1
Vertical	28.2	119.9

(2) Distances Travelled in Feet:

Distances Travelled per stow/issue	Fast	Slow
Vertical average distance	7 ft	3 ft
Horizontal possible	16.3 ft	28.2 ft
Average horizontal travel travelled during vertical travel	8 ft	14 ft

The vertical time required per stop is 557 TMU's. The average horizontal distance travelled is computed at half the possible distance travelled during the 557 TMU's, or 22 feet.

b. Variable Times

Variable time is the time required to complete the horizontal distance not travelled during the vertical time required for picks/stows, plus the time to travel from the take-away line to the accumulation line once every cycle, plus the fractional time required for initialization/disembark travel.

(1) Travel Time for Initialization/Disembarkation

This travel time must be computed to account for the time it takes to travel once an operator initializes the MS/RM at ground level at the end of an aisle, until he gets to the accumulation line (which is the point where a cycle begins), and the travel from the take-away conveyor to the disembarkation point back to the ground level starting position.

Travel time (fast to accumulation area (24')	677 TMU's
Travel time (slow) to accumulation conveyor (3')	360 TMU's
Travel time (fast) to disembark (19')	536 TMU's
Travel time (slow) to disembark (3')	360 TMU's
Total Vertical Travel Time	1933 TMU's

(2) Vertical Time from Take-away to Accumulation Conveyor. This travel must be computed once for every cycle of the MS/RM. The distance from the take-away conveyor to the accumulation conveyor is five feet. As the same rules about travel speeds apply to this part of the cycle, the distance from the take-away conveyor is converted to times and are as follows:

Three feet slow speed	=	359.7 TMU's
Two feet slow speed	=	56.4 TMU's
Total Time Required		416 TMU's

(3) Horizontal Travel Time not Travelled During Vertical Travel. The horizontal travel needed to complete the cycle (which the author calls the "free" horizontal travel time) is computed by taking twice the possible horizontal travel which is possible during the vertical

travel for one cycle, and dividing by the total number of stops per cycle. The horizontal travel which is possible under a method of efficient picking directed by the console of the MS/RM during one cycle is 189 feet each way [Ref. 3]. The average horizontal distance travelled per stop is 22 feet. Each cycle will have stops for picks, stows, and one stop for the start/stop point. In the example of four picks and one stow per cycle, the number of stops would be six.

First, the amount of travel time to travel the free horizontal distance is computed:

((189' * 2)-(22 * 6)) * 6.6 TMU's per foot = 1624 TMU's

This horizontal travel time is added to the 416 TMU's required to travel the vertical distance from take-away conveyors to accumulation conveyors, and the fractional time required for travel vertically when the operator initializes/disembarks computed per cycle.

E. COMPUTE TOTAL CYCLE BASE TIMES

The total cycle base time can now be computed. The total cycle time will include the pick constant times multiplied by the number of picks, the pick variable times, the stow constant times multiplied by the number of stows, the stow variable times, the vertical travel times adjusted by the number of stops, the free horizontal time, the time needed to travel from the accumulation conveyor to the take-away conveyor, and the per cycle fraction of the

initialization/disembark process and travel times. These times are computed as follows:

Pick Constant Time	(1604 + 244) * 4	=	7392 TMU's
Pick Variable Time	387 * 1	=	387 TMU's
Stow Constant Time	(1205 + 479) * 1	=	1684 TMU's
Stow Variable Time	337 * 1	=	337 TMU's
Vertical Travel Time	557 * 6	=	3342 TMU's
Free Horizontal Travel Time		=	1624 TMU's
Take-away/Accumulation Travel Time		=	416 TMU's
Initialization/Disembark Process Time	(750/5)	=	150 TMU's
Initialization/Disembark travel time	(2031/5)	=	387 TMU's
Total Cycle Base Time			15,719 TMU's

F. COMPUTE ALLOWANCE FOR PFD

The allowance for personal, fatigue, and unavoidable delays is computed through the guidance of Appendix II. The allowance computed in this example assumes normal warehousing conditions, and the worker changing locations of work once every hour.

1. Personal Allowance

The personal allowance computation includes time (basic allowance) for two 10-minute coffee breaks per day, restroom breaks, and other human requirement times. Additionally, time is included for poor heating and other additional times for personal or work area cleanup which is permitted.

Basic allowance	4.2%
Slightly disagreeable conditions	3.0%
Five minute cleanup per day allowed	1.0%
Total Personal Allowance	8.2%

2. Fatigue Allowance

The fatigue allowance computation requires several steps. As the materiel being stored in the rackables area is larger than a softball, and weighs less than 55 pounds, it is assumed the average weight to be picked or stowed is eight pounds. That weight is considered too small to increase the percentage of fatigue allowances above the minimum considered practical listed in Appendix II. The percentage of time this weight is handled is computed by adding the times in the cycle which the worker will be under load (4539 TMU's in this example), and dividing it by the total number of TMU's in the normal cycle (15,719). This provides a 28 percent work time which the worker will be holding or manipulating the weight of materiel handled.

Average eight pound pkgs handled 28% of time	2%
Mental work requires full attention	2%
Light provided is less than 75 foot candles	2%
Noise is constant and over 60db	1%
Total Fatigue Allowance	7%

3. Allowances for Delay

Isolated job	1%
Balancing delay, move once every 60 minutes	2%
Total Delay Allowance	3%

A balancing delay is a delay which occurs due to a slowdown in work caused by one or more operations in a series due to imperfect balancing, such as that found with a worker shifting from one location to another [Ref. 19: A-IV-7].

4. <u>Compute the Modifier</u>

The total PFD allowance is equal to 18.2 percent. According to Appendix II, this 18.2 percent allowance must be entered into a formula to compute the base time modifier which is used to convert the base time into a standard time. That formula is:

$$100/(100 - \text{PFD allowance}) = 100/(100-18.2) = 1.222$$

The standard time will be the product of the base time and this modifier.

G. DETERMINE AVERAGE CYCLE TIME DURING NORMAL DEMAND

The average times for the primary example can now be determined. The following illustrates how the constant times and variable times for the previous scenario are incorporated and adjusted to reflect the PFD allowance.

1. <u>Determine Average Pick Time</u>

Constant Pick Time per Cycle	Base Time
Pick time from aisle	1604 TMU's
Place on take-away aisle per pick	244 TMU's
Vehicle travel time, vertical	557 TMU's
Total Constant Pick Time	2,405 TMU's
Variable Pick Time per Pick	
Place on take-away (387/4)	97 TMU's
Vehicle horizontal free travel (1624/5)	325 TMU's
Take-away/accumulation travel (416/5)	83 TMU's
MS/RM initialization time (150/5)	30 TMU's
MS/RM initialization travel (387/5)	77 TMU's
Total Variable times per pick	612 TMU's
Total Base Time per pick	3017 TMU's
Total Standard Time per pick = 3017 x 1.222	3687 TMU's

2. Determine Average Stow Time

Constant Stow Times

Stow time from MS/RM	1205 TMU's
Accumulation line time expended	479 TMU's
Vehicle vertical travel time	557 TMU's
Total Constant time per stow	2224 TMU's

Variable Stow Times

Accumulation line variable time	387 TMU's
Vehicle horizontal free travel(1624/5)	325 TMU's
Take-away/accumulation travel (416/5)	83 TMU's
MS/RM initialization time (150/5)	30 TMU's
MS/RM initialization travel (387/5)	77 TMU's
Total Variable stow time	902 TMU's
Total Base Time per stow	3126 TMU's

Total Standard Stow Time 3126*1.222 = 3820 TMU's

3. Compute Cycle Times

The total cycle time for four picks and one stow, under normal conditions, can now be computed as:

(4 * 3687) + (1 * 3820) = 18,568 TMU's = 11.14 minutes

This 11.14 minutes would be added to the worker's other duties to compute his expected work output per day. Assume the worker is assigned to make issues and stows in adjacent MS/RM aisles for the entire eight-hour day. During that day, the worker could be reasonably expected to board nine MS/RM machines, and make 42 cycles on those machines. The time required to walk between aisles is accounted for by the balancing delay, which is designed to account for the time for a worker to move from one station to another. This delay assumes the stations are at floor level.

4. Compute Labor Requirements

For every man assigned to the operation of MS/RM's, a total of 172 picks and 43 stows can be expected per shift. If the anticipated number of receipts and issues are 80 and 320 respectively, two men should be assigned to the MS/RM's. If the anticipated workload is 240 picks and 60 stows, two men should be assigned to the MS/RM's during half the day, and only one man the other half-day. The second operator could be assigned to some other job in the warehouse. This presumes any problem due to random arrivals of picks would be resolved during the following shift. A queue of such picks could continue to grow even though the worker can handle the average needed output of materiel.

H. DETERMINE AVERAGE CYCLE TIMES DURING HEAVY DEMAND

Expected throughput during high demand conditions can also be computed. To compute maximum throughput per employee, such as that which would be expected during a national emergency, minor adjustments can be made to the computations, and anticipated maximum throughputs can be forecasted. In such a situation, the operating scenario is assumed to be eight picks and two stows per cycle.

The allowance for PFD would be reduced by two percent, as it is assumed the MS/RM's would be fully manned, and workers would stay on the same MS/RM, and thus, the balancing delays would no longer be applicable. The new PFD allowance would be 16.2 percent. Base constant times would

be the same, and variable times would be altered to reflect a new anticipated work scenario providing allowances for the additional activity during the same period of time. The free horizontal time would be reduced because of the increased number of stops per cycle, and the vertical times between the accumulation line and take-away and the appropriated time for initialization of the MS/RM machine would be divided by ten. The following illustrates the results.

1. Compute Average Pick Times

Constant Pick Time per cycle	Base Time
Pick time from aisle	1604 TMU's
Place on take-away conveyor per pick	244 TMU's
Vehicle travel time, vertical	577 TMU's
Total Constant pick times	2405 TMU's

As mentioned above, the constant times would stay the same. Additional horizontal distance will be travelled, however, during the additional stops for stows and issues. The free horizontal distance would now be computed as:

(378') - (22 * 11 stops) = 136 feet

This 136 feet would be travelled in 898 TMU's

Variable Pick Time per Cycle	
Place on take-away 387/8	48 TMU's
Vehicle horizontal free travel (898/10)	90 TMU's
Take-away/accumulation travel (416/10)	42 TMU's
MS/RM initialization time (150/10)	15 TMU's
MS/RM initialization travel (387/10)	39 TMU's
Total Variable times per pick	234 TMU's
Total base time per pick	2639 TMU's

The new modifying factor is computed 100/(100-16.2)= 1.193. Total standard pick time = 2639 * 1.193 = 3148 TMU's

2. Compute Average Stow Times

Constant stow times

Stow time from MS/RM	1238 TMU's
Accumulation line time expended	429 TMU's
Vehicle vertical travel time	557 TMU's
Total constant time per stow	2224 TMU's

Variable stow times

Accumulation line variable time	194 TMU's
Vehicle horizontal free travel (1624/10)	90 TMU's
Take-away/accumulation travel (416/10)	42 TMU's
MS/RM initialization time (150/10)	15 TMU's
MS/RM initialization travel (387/10)	39 TMU's
Total variable stow time per stow	380 TMU's
Total base time per stow	2604 TMU's

Total standard stow time = 2604 * 1.193 = 3107 TMU's

3. Compute Cycle Times

The total cycle time can now be computed by (3148 * 8) + (3107 * 2) = 31,398 TMU's To convert 31,398 TMU's to minutes, divide by 1667 TMU's to obtain 18.83 minutes to pick eight issues and stow two stows. An average of 25 cycles per day can be made from a dedicated worker on one MS/RM which will allow 200 issues to be picked, and 50 stows to be made per day under heavy operating conditions. As there are 12 rackable aisles, if each aisle is manned, and the eight picks/two stows per cycle is maintained, the expected output of materiel during heavy usage through the rackable aisles becomes 2,400 issues and 600 stows.

An argument could be made that the MS/RM initialization and initialization travel times would no longer be significant in this scenario. This author believes that a

portion of these travel times will still be needed for personal needs, and the operator still occasionally needs to leave the machine.

I. COMPARISONS BETWEEN POTENTIAL WORK METHODS

Further scenarios are now a simple matter. Assume the eight picks and two stows routine is normal, and that the operator changes MS/RM's once per hour. The 18.2 percent allowance is made to all base times and added. An example of this procedure follows:

Average pick time = 2639 * 1.222 = 3225 TMU's

Average stow time = 2604 * 1.222 = 3182 TMU's

Comparisons can now be made to determine the amount of time saved by utilizing eight picks and two stows, rather than four picks and one stow cycle as the normal routine cycle. The savings in time between the methods are:

4 Picks/1 Stow = (4 *3687 + 1 x 3820) * 2 = 37136 TMU's

8 Picks/1 Stow = 8 * 3225 + 2 * 3182 = 32165 TMU's

The shift from a normal working pattern of four picks/ one stow to one of eight picks/two stows would increase employee productivity by 15 percent. Although some savings might have been expected intuitively, the magnitude of quantified increase might not have been.

The computation of various scenarios can continue to allow management to determine the expected output of various patterns of work. The variable times will continue to decrease slightly as the number of picks and stows per

cycle increases, however, the time expended to pick the correct stow from the MS/RM might increase because the worker may have to sort through the additional stows to find the right one. Finally, the storage space on the MS/RM will limit the maximum number of picks and stows.

VII. ADDITIONAL CONSIDERATIONS IN ESTABLISHING STANDARDS

There are additional considerations which should be included when establishing standard times. The implementation process should be an effort of both management and employees. Once standards have been implemented, they cannot be forgotten. A continual audit must ensue so that standards do not become outdated. After the standards are implemented, an opportunity exists to obtain even further productivity through the use of incentive plans using those time standards as a base. This chapter will briefly discuss these concepts.

A. NEED FOR EMPLOYEE/UNION INVOLVEMENT IN IMPLEMENTATION

There is a strong need for employees or unions to be involved in the establishment of work standards. If a work standard program is to succeed, it is important that all participants understand it, and believe it will be administered fairly and without detriment to the welfare of the employees. Without that underlying belief, there is likely to be resistance to the implementation or success of the program. Resistance may occur for a variety of reasons, including threatened self-interest, a distorted perception of the intended change, rational disagreement with the reason for the change, resistance to a perceived loss of freedom, or low tolerance to change [Ref. 26:51].

There are a number of techniques for dealing with change. Participation in the development process can provide a sense of "ownership" in the change. Education also is among the most effective means.

There will be some real concerns among employees with regard to the design of any work measurement program [Ref. 27:29]. They include:

--Does the standard time afford allowances for personal time, normal time, and delays?

--Was the same method of measurement applied uniformly to everyone doing similar work?

--What is an acceptable level of performance (percentage)?

--Is the 100 percent standard consistent with universally accepted standards?

--What is the normal work pace?

--What will happen if standards are not met?

These and other questions need to be addressed directly and honestly with employees. They need to be told exactly what use the times standards will serve, and how it will affect their jobs.

B. AUDITS OF TIME STANDARDS

Standard times should reflect real world conditions. It is an obvious fact that the world is in a continuous state of change. Accordingly, standards will need to be audited and changed to reflect those changes.

1. What Changes Require Auditing?

Some changes which will require auditing are obvious, and those audits should occur when those changes are noted. Changes in equipment or methods are examples of such obvious changes. Other changes will occur from variables which are far more subtle, and will occur even without changes in personnel, methods, or equipment. The list includes, but is not limited to the following [Ref. 25:452-455]:

a. Average frequencies of occurrence per cycle, such as the number of picks and stows which occur in one trip of the picking operation.

b. Sequence with which stowage locations are selected, changing the amount of travel time for the average pick.

c. Power availability for battery powered equipment, as the power and speed of equipment will ebb with usage.

d. Equipment age.

e. Equipment condition.

f. Equipment maintenance.

g. Traffic conditions

h. Obstructions.

i. Pavement conditions.

j. Average weight of the load.

k. Average size and shape of the load.

l. Loading area conditions.

m. Lighting.

n. Housekeeping.

o. Temperature.

p. Weather.

q. Humidity.

r. Background noise levels.

s. Color of the room.

t. Air freshness.

2. <u>Periodicity of Audits</u>

How often should standards be adjusted or audited? There are no apparent DOD directives which give guidance as to the frequency which standards should be audited at the user level.

Most companies (74 percent) who audit standards do so on a random rather than a scheduled basis. A survey conducted in 1976 of companies using standards indicated audits were conducted primarily through the use of time study or performance reports. Most companies who had established standard times for indirect labor would revise those standards if an audit indicated their standard times were in error by over a range of four percent to six percent [Ref. 28:22].

Certainly the ABC concept should be considered. The ABC concept applies when most of the total activity is found in a small portion of the operations to be studied. For example, the picking activity is certainly going to occur more frequently than the researching of frustrated materiel, and the frequency of audits should reflect those differences.

One large company uses the following data to determine the frequency of the audit of methods and standards:

Labor Hours Expended in Activity Per Year	Frequency of Audit
1-10	Once every three years
10-50	Once every two years
60-600	Annually
Over 600	Twice annually

It is recommended that audits for an indirect labor program such as a warehousing activity should be conducted in depth by management no less than once annually, in addition to the obvious change requirements [Ref. 25:70].

C. INCENTIVE PLANS IN WAREHOUSING

People have at least two speeds which they will work. One, which can be called the normal pace, is the speed at which an average well-trained person familiar with the work would go about his duties without any inducement to work at a faster pace. The other, which can be called an incentive pace, is the speed which an average well-trained person, familiar with the work, would go about his duties after being induced to work faster. The manner in which most companies induce their employees to work faster is called an incentive plan [Ref. 29:116].

1. Impact of Incentives Programs

The use of incentive programs in some cases had drastically improved employee productivity in warehousing activities. The use of an incentive program utilizing time off as an incentive for pickers at Certified Grocers'

Ltd. of California prompted Bob Walter, Vice President of Distribution, to indicate he:

> . . . wouldn't implement a standards program without an incentive plan. I hesitate to use figures, but we've realized a 15 to 20 percent increase in the productivity of our order pickers, at no other cost whatsoever. [Ref. 30:50]

John Deere uses an incentive plan in addition to a very sophisticated time standards program. Small parts picking productivity in their distribution warehouse doubled after implementation of their program [Ref. 31:38].

London Fog implemented an incentive plan coincident with the consolidation of four distribution facilities. By covering 80 percent of their labor force with incentives, they doubled productivity, decreased error rates to .1 percent, and substantially improved customer services [Ref. 32:62]. Despite the impressive gains made by these and other warehousing activities, it is estimated less than 5 percent of all distribution centers use incentive plans.

2. Types of Incentive Plans

Individual incentive plans have traditionally been a method of providing incentives to workers. An individual incentive plan is one which rewards each individual for his own performance, regardless of the effect on the total output of the company. Individual incentive plans provide the most direct form of rewarding the most productive employees, and the potential for the highest productivity for any given employee. An employee seeking a maximization of his

individual earnings may, however, hinder progress of fellow employees who seek his cooperation in fulfilling their own job requirements. If there is a large degree of interaction between employees, this self-serving behavior may hinder the performance of the entire organization.

Group incentive plans reward a group of people working in a combined effort toward the common goal of that group. Group incentive plans promote harmonious work flows among employees, because the performance of any employee within the group affects the income of another. Group incentives appear to work best in smaller groups where an individual can perceive the impact of his own participation and where social values attached by fellow workers can serve as an added incentive [Ref. 33:346].

Group incentive plans do have some drawbacks. Such plans provide rewards for those who do not provide their full measure of effort, and, if the social pressures imposed by coworkers do not affect the individual, a low performing worker can be rewarded. This injustice can promote disharmony and conflict within the group. The hardest workers are not compensated in proportion to their effort, and this may promote less than the fullest effort to be expended by that group [Ref. 34:35-37]. Groups also may tend to resist the introduction of new employees, desiring not to pay for the newcomer's learning curves.

Not all incentive systems are based on money alone. Some effective systems provide time off in lieu of extra pay.

As mentioned earlier, Certified Grocers' of California, Ltd. uses time off as an incentive for their pickers. If the incentive is small (say two percent), it has been determined that most employees would prefer time off [Ref. 35:1]. If the amount is significant, however (exceeding ten percent), the typical warehouseman would prefer to see an increase in salary [Ref. 36:1-16].

3. Common Elements of a Successful Pay Plan

There are several elements which seem to appear consistently in successful plans. They include:

a. Ownership of Incentive Plans by Employees

One common element is a feeling of ownership, both by employees and by management. Studies have indicated incentive plans are more effective if they have been participatively developed, rather than imposed on a group of employees [Ref. 37:468].

b. Ownership of Plan by Management

One followup study of incentive plans established by outside researchers for companies discovered two cases where management had discontinued these pay incentive plans, despite knowing discontinuance of the plan would cost the company more money in increased hourly wages than it saved in unpaid bonuses. The apparent reason was that since management had little to do in developing the plan, they felt little commitment to the success of that plan [Ref. 38:185].

c. Benefits to Both the Company and Employees

For any plan to be successful, both parties must benefit from its implementation. This means the company must see savings from wages above the cost of implementing the program, and the individual must be capable of earning above the base rate.

d. The Plan Should Be Simple

Trust of a plan is significantly facilitated by an understanding of the plan from all concerned. In general, the plan with the most simple mathematics has the best chance of acceptance [Ref. 39:7].

e. Protection from Rate Cuts

Once an incentive plan is in operation, it becomes a viable target for budget reductions. Clear understanding of management that incentive plans are tools which save money for the company will help in this area [Ref. 39:8].

f. Earnings not Affected by Outside Factors

Earnings should not be affected by factors beyond the control of the worker. The worker must not be penalized for delays caused by lack of an opportunity to perform, such as equipment failure. Times which are controlled entirely by machines should not penalize the worker [Ref. 39:8].

4. Why Incentive Plans Fail

It is worth note that while identical incentive plans are successful in some situations, they fail in

others [Ref. 40]. There appears to be numerous reasons why incentive plans fail. However, these failures often can be traced to one of four basic reasons [Ref. 41:53-60].

a. Improper Design

The plan was improperly designed. The design could be poor as a result of inconsistent standards application, ineffective job evaluation, or inadherence to proper procedures in setting standards.

b. Poor Administration

The plan was poorly administered. Poor administration can result from management's misunderstanding the policies, methods improvements, human behavior, or concept of work measurement. It is easy for management to authorize deviations to the incentive program when occasional low performance is apparent and there is worker pressure to do so.

c. Poor Maintenance

Poor maintenance of standard times can be a reason why incentive plans fail. Once it is in place, it is easy to allow a time standard to remain without auditing. There are constant demands for management's attention, and the demand for auditing standards often is not distinct.

d. Poor Installation

Improper installation can cause the best incentive program to go astray. The promise of large increases in productivity can create pressures to accelerate the

implementation of an incentive plan, and "shortcuts" can lead to disaster.

5. Measurement

Productivity does not necessarily need to be based strictly on the quantity of work performed. Quality and accuracy of the work also can be included. A simple method of implementing accuracy into picking standards would be to multiply the incentive pay earned by the percent of accuracy of picks, both in quantity picked, and the right item being picked. The implementation of quality standards should be as thoroughly researched and planned as any other portion of an incentive plan. Errors detected must be due solely to the operator, and not from any other factor(s). Additionally, the increased sophistication of the formula used in determining the incentive pay may, to some degree, reduce the understanding and confidence of the individuals involved in the plan.

It is not necessary to be able to measure objectively all worker efforts for the system to be workable. Seventy percent measurement of a certain job may be enough to be indicative [Ref. 42:36]. It is important that the job measured is controllable by, and identifiable to, the recipient of the incentive; and that the time standards which constitute satisfactory performance are objectively developed.

6. Conclusions

Employees are motivated by a number of factors: esteem, respect, and tangible rewards. Tangible rewards can be provided systematically, objectively, and efficiently by management as a motivating factor. Necessary features of a reward system, regardless of the type of system, have been discussed.

Incentives are not a cure-all. There are significant costs in developing and maintaining a good incentive plan. Incentives do not replace good management. Managers must continue to be managers, and not become expediters in an attempt to boost productivity of individual employees at the cost of time and foresight which should have been used in the planning process. In instances where incentives have been well-implemented, and are understood and trusted by all and are well-maintained, there is evidence that both management and employees have benefitted by their use.

VIII. CONCLUSIONS AND RECOMMENDATIONS

A. GENERAL

The use of standard times in warehousing has a long history in the Department of Defense. Additionally, the use of standard times in warehousing activities has been shown in several instances to provide significant reductions in manpower and equipment costs. Despite precedence of use and established potential savings, NISTARS has not utilized accurate standard times in their activities. This is symptomatic of the general ambivalence for standard times which is characteristic within the warehousing industry.

There have been arguments that warehousing activities are too varied to have standards established, and that standard data is too involved and complicated for application to warehouses. However, automated warehouses, such as that found at NISTARS, have formalized and routinized a great deal of the work performed, and therefore, this first argument tends to have little validity.

It is this author's belief that the movement toward automation of warehouses also has substantially increased the potential for use of standard data in establishing work time standards for the various activities performed in a warehouse. As a consequence, this thesis has attempted to demonstrate the feasibility of establishing standard

times at NISTARS warehousing activities, and to show that these time standards can be used to establish manning requirements, obtain increased productivity, and provide more accurate projections of materiel movement than that which now exists.

B. SUMMARY

This thesis has examined standard times, the history of standard times, and current uses of standard times. Specific examples have been provided of documented benefits enjoyed by companies through the use of standard times. Various methods of establishing standard times (especially those which have been most useful) have been described. The use of computers, both in implementation and maintenance of standard times, was discussed. Emphasis has been given to government sources of standard time information, and the more pertinent areas within those sources were indicated. Steps in establishment of time standards were discussed, and an example demonstrating the creation of a standard time was provided. The need for employees to be involved in the implementation of time standards has been pointed out. The requirement for proper maintenance of standard times through auditing was stressed. This thesis additionally described incentive programs useful in conjunction with time standards at NISTARS.

C. CONCLUSIONS

Accurate time standards will insure the maximum level of performance, because they have proven to be an efficient and effective means of estimating materiel throughput, manpower requirements, and equipment requirements. Additionally, the mere use of time standards has had a tendency to increase productivity significantly.

In setting and maintaining standard times, the use of computers is rapidly spreading in those companies which currently have standard times programs. Computer programs store and manipulate data at a rate significantly faster than has previously been done manually. The greatest savings in the use of computers has been in the maintenance and updating of standards, rather than the original generation of those standards. Software programs such as ADAM and CSD, which have been written expressly for establishment and maintenance of standard times, are extremely beneficial in establishing standard times at NISTARS.

The use of standard times certainly will interest both employees and union representatives who support those employees. Organized labor's resistance halted the early uses of work measurement. There remains a great deal of concern about its possible use, or misuse, today.

Early involvement and education of employees regarding the use of standard times has proven to be beneficial to its success. The establishment of time standards should

not be imposed upon employees by management, but should come about as a cooperative effort. Knowledge of the standards, and a sense of involvement by employees, will greatly enhance the chance of success of this program.

Once standard times have been implemented, it is imperative that they be kept current. This is one major area in common which successful standard times programs have in more progressive warehousing activities.

Any changes in design of equipment or procedures should generate an audit of existing time standards. Additionally, audits of established standards should be conducted not less than annually to ensure any change(s) which may have gone undetected by management are reflected in the warehouse standard times.

The use of time standards at NISTARS may open additional potential for increased productivity through incentive programs. Both management and employees in other companies have benefitted from the use of incentive programs through increased productivity, higher wages, and reduced costs to the company. There is no reason to assume these same benefits could not be realized by management and labor at NISTARS. The steps in implementing an incentive program, and maintaining that incentive program, are not unlike those of standard times programs.

D. RECOMMENDATIONS

It seems fitting that a modern, progressive material handling system (such as that found at NISTARS) should also have a progressive management technique of forecasting manpower and equipment requirements. This only can be done through the accurate quantification of labor. The creation of standard times, using standard data, is both cost-effective and efficient.

It is recommended that time standards be generated for NISTARS activities, using this thesis as a guide. These standards then should be implemented in cooperation with the union (or other representatives of the employees.

It also is recommended that management at NISTARS seriously consider use of microcomputers and software currently available (such as CSD or ADAM) in the implementation and maintenance of standard times. Once implemented, the use of computers will significantly reduce the cost of maintaining standard times.

A further recommendation is that once NISTARS is functioning, and standard times have been validated, that NISTARS management investigates the use of those time standards as a basis for an incentive program to achieve increased productivity.

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